

FEDERAL REPUBLIC OF GERMANY

GERMAN PATENT OFFICE

Patent Application Open to  
Public Inspection  
DE 37 11 470 A1

Int. Cl.<sup>4</sup>:  
**B 23 K 26/00**  
**B 23 Q 35/40**

File number: P 37 11 470.0

Application date: 4.4.87

Disclosure date: 27.10.88

**Applicant:**

Fraunhofer-Gesellschaft zur Förderung der  
angewandten Forschung eV, 8000  
München, DE

**Inventors:**

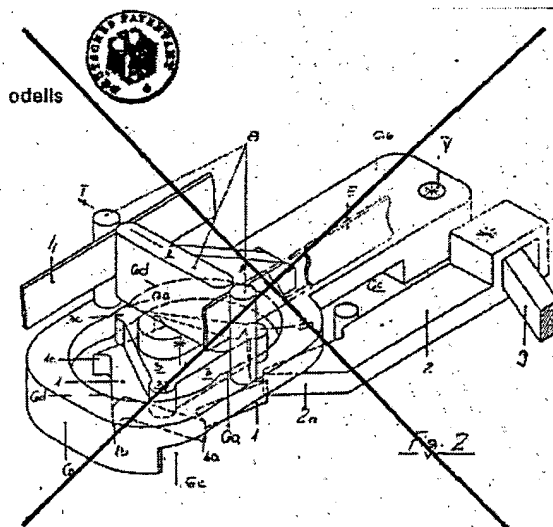
Beyer, Eckhard, Dr. Dipl.-Ing.; Klein, Rolf,  
Dipl.-Ing., 5100 Aachen, DE; Herziger,  
Gerd, Prof. Dr.-Ing., 5106 Roetgen, DE

Testing application is made according to § 44 PatG.

Process to manufacture a three-dimensional model

Process to manufacture a three-dimensional model, especially a vehicle model, which is comprised of a variety of slices that have model contours and are manufactured from plate material by a process that removes material.

In order to quickly and cost-effectively manufacture models, especially of vehicles, the model contours are produced by processing the plate material with laser beam.



**BEST AVAILABLE COPY**

## Patent Claims

1. Process to manufacture a three-dimensional model, especially of a vehicle, which is comprised of a variety of slices that have model contours and are manufactured from plate material by a process that removes material; wherein the model contours are manufactured by processing the plate material (12) with laser beams.
2. Process according to claim 1, wherein slice blanks (13) are cut out of the plate material (12) using a laser beam (14), whereby the laser beam (14) is brought to the plate material (12) vertically and/or angled toward the model shape (18).
3. Process according to claim 1 or 2, wherein the slice blanks (13) are joined into a rough contour model which is polished by hand and/or by laser beam afterwards, if necessary.
4. Process according to claims 1 to 3, wherein the predefined model shape (18) is divided into slices (11) by a computer (16), and the computer (16) calculates the contour values of the model shape (18) for each slice thickness (17), and correspondingly impacts the laser beam (14) while cutting the slice blanks (13) and/or while polishing the rough contour models (15).
5. Process according to claims 1 to 4, wherein after every addition of a slice blank (13), the actual contour value is compiled and the impact of the laser beam (14) is appropriately corrected, if necessary.
6. Process according to claims 1 to 5, wherein the contour lines (21) formed by the slice sides (19) and/or edges (20) are used as the contour value of the model shape (18).
7. Process according to claims 1 to 6, wherein a distance measuring system is used to control the optics focusing the laser beam (14) on the rough contour model (15) and/or a laser performance system is used to control scaling of the laser (23) when polishing the rough contour model (15).

8. Process according to claim 7, wherein the performance of the laser (23) and/or its switch-on duration are used for scaling.
9. Process according to claims 1 to 8, wherein the slice blanks (13) are joined onto fixing rods (24) of a movable platform (26) provided with a scraper (25).
10. Process according to claim 4, wherein the model shape (18) is divided into sub-areas (27) in which the division of the slices (11) occurs in slice levels differing from each other.
11. Process according to claims 1 to 10 wherein plastic and/or metal are used as plate material (12).

## 2

### Description

The invention relates to a process to manufacture a three-dimensional model, especially a vehicle model, which is comprised of a variety of slices that have model contours and are manufactured from plate material by a process that removes material.

When manufacturing vehicle models for wind tunnel tests and styling studies, an expensive milling process is used in order to carve out models in 1:1 ratio from polystyrene blocks that must be manually polished afterwards. The milling process is not only expensive but the manufacturing of a model also takes a proportionally long time.

Therefore, the task of the invention is to create a process to manufacture a three-dimensional model that permits quick and cost-effective production. This task is solved by manufacturing the model contours by processing the plate material with a laser beam in a process with the input of specified characteristics.

For the invention, it is significant that the three-dimensional model is no longer produced from one piece, but rather is a composite of a variety of slices that have the model contours. Such slices can be produced using laser

beam, so by a process that removes material, by evaporating material with the energy of the laser beam.

It is an advantage that slice blanks are cut out of the plate material using laser beam, whereby the laser beam is brought to the plate material vertically and/or angled toward the model shape. Manufacturing slice blanks enables a quick first attempt at those slices that will have model contours in the end. The vertical guidance of the laser beam to the plate material is sufficient for this if the slice blank only needs to be minimally accurate or the model contour is sufficiently close using vertical beam guidance. The slice blanks can be produced even more precisely using a laser beam angle adjusted to the model shape to the plate material, especially if the slice edges are angled or the plate material is relatively thick.

The slice blanks are joined into a rough contour model that is polished by hand and/or by laser beam afterwards, if necessary. Manual polishing may be sufficient if the rough contour model could approximate the desired final model as closely as possible. Polishing with laser beam occurs mainly in order to quickly refine relatively rough contours, and is especially suited for use in automatic or steered processes.

In order to use the advantages of electronic or computer supported production, the determined model shape is divided into slices by a computer, and the computer calculates the contour value of the model shape for the respective slice thickness and impacts the laser beam while cutting the slice blank accordingly and/or while polishing the rough contour model. The manufacturing process of the model thus begins with saving the model shape in a computer. Then it is divided into slices with the aid of a program that can consider the contour accuracy, for example. Then the contour values of the model for the respective slice thickness are calculated using this program in order to appropriately steer the laser beam.

After every addition of a slice blank, the actual contour value is compiled and the impact of the laser beam is appropriately corrected, if necessary. As a result, tolerances of the plate material or those required from assembly of the slice blanks can be considered in order to approximate the rough contour model of the desired model shape as closely as possible.

The contour lines formed by slice sides and edges are used as contour values of the model shape, if these contour lines sufficiently accurately portray the contour lines of the contour values.

A distance measuring system is used to control the optics focusing the laser beam on the rough contour model and/or a laser performance system is used to control scaling of the laser when polishing the rough contour model. In this manner, polishing can be automated, because the desired model shape is stored in the computer, and as a result, the target value formation can be used. The performance and/or the switch-on duration of the laser are used as scaling so that the intensity of the laser beam and/or its impulse parameter can be influenced.

The slice blanks are joined onto fixing rods of a movable platform provided with a scraper. Using this movable platform not only simplifies true-to-scale joining of the slice blanks, but also the compilation of actual contour values from this movable platform.

The model shape is divided into sub-areas in which the division of the slices occurs in slice levels differing from each other. As a result, individual areas of a model can be manufactured with minimal expense from wearing away material.

Plastic and/or metal are used for plate material. The plastic can be evaporated comparatively easily by the energy of the laser beam. Using metal permits especially sharp contours to be produced true-to-scale. However, other materials can obviously also be used to manufacture models or parts that are true-to-contour, such as ceramic or glass.

The invention is described more closely using models, arrangements and processes shown in the drawing. Therein:

**Fig. 1** a schematic representation of a process to manufacture a model,

**Fig. 2** an excerpt of the process in fig. 1, including model representations,

**Fig. 3** a representation to guide a laser beam,

**Fig. 4** a representation to further describe a process to polish the model and

**Fig. 5** a vehicle model with several differently layered part areas.

According to the production process shown in fig. 1, a computer 16 is present as a component of a so-called CAD system. Model shape creation 30 occurs using this system or a computer program, and the model shape 18 can

be saved, compare fig. 2. A fixed point compilation 31 is implemented using the computer 16, which is used to divide the model shape 18 into slices 11, whereby the slice division 32 considers the design of the model shape 18, and the computer 16 only considers part area 27, if necessary, compare fig. 5.

After dividing the slices 32, the slice blanks 13 are cut out 33, and afterwards the slice blanks 13 are joined into a rough contour model 15. After joining 34 the slice blanks 13, the measured values are recorded 35 for the rough contour model 15. The compiled contour values are entered into the computer 16 that appropriately controls cutting out 33 additional slice blanks 13.

Once the rough contour model 15 is finished, a precise contour is manufactured 36 either by polishing 37 by cutting with the laser beam or manually reprocessing 38 by puttying and grinding.

Fig. 2 illustrates the process steps 32 to 35 with part representations of the objects necessary for this. The model shape 18 is represented on a screen 39 of the computer 16 to index the slices. The part area 27 forming the front area of the model shape 18 is excluded from slice indexing. The slice indexing occurs from fixed point 31. Afterwards, the contour values of the model shape 18 for the selected thickness 17 of slice 11 are calculated at slice indexing 32, whereby the contour lines 21 serve here as contour values, which are formed by the slice sides 19 and the slice edges 20, according to fig. 3. In fig. 2, it is assumed that both contour lines 21 are the same for simplicity's sake in representation.

Cutting out 33 a slice blank 13 occurs according to fig. 2 with a laser 23, whose beam 14 is focused with a processing optic 22 on the plate material 12. To cut out the slice blank 13, a computer controlled multiple axle beam guidance system, which guides the laser beam 14 so that it already forms a connection line between two contour lines 21.

Fig. 3 shows a beam guidance vertical to the plate material 12 so that a cutting join vertical to the side surface 19 with corresponding vertical cutting edge 20 results. With the beam guidance, also shown in fig. 3, angled to the plate material 12, a correspondingly angled slice edge 20 results.

A movable platform 26 serves to join the cut-out slice blanks 13 into a rough contour model. The movable platform has a floor 40, a rear wall 41 and a scraper 25. There are fixing rods 24 parallel to each other, that are arranged parallel to the floor 40, and which permit placing the slice blanks 13 one after the other. These slice blanks 13 are, for example, joined together with slight press fit onto the fixing rods 24 or by gluing them to each other. Through slice tolerances and/or adhesive application, a somewhat larger dimension than calculated results in direction of the fixing rods 24, so that as a result, the inaccuracy present must be considered by compiling 35 the actual contour values or contour lines 21 before slice indexing 32 for an additional slice blank 13. After finishing the rough contour model 15, it is pushed down from the fixing rods 24 with the scraper 25, if no precise contour manufacture will follow.

A precise contour manufacture is further described in fig. 4. There the outer or rough contour of a part 15' of the rough contour model 15 is designated as the actual contour, to which should be processed with the laser beam 14 in order to achieve the target contour, so the model contour of a model shape 18. In order to do so, the energy of the laser 23 is focused on the part 15' or the material to be removed using processing optics 22. The laser beam 14 there has the desired energy density in order to evaporate the material to be removed.

The laser 23 creates a pulsating laser beam 4, which affects with an impulse or a specific number of  $Z_{MESS}$ . This value or the distance between the target and the actual contour is transmitted with a distance measuring system and is entered into the process data processing 42 according to fig. 4. In addition, the processing optics 22 functions with a laser performance measuring system with which the  $Z_{MESS}$  value was achieved. The laser performance value is also entered into the process data processing 42. In addition, the processing data processing 42 is provided with the respective values  $Z_{SOLL}$ , which only serve to control the processing optics 22 in only one direction  $z$ , for example, but actually affect all values with which the model shape 18 is characterized. The values presented in fig. 4 occur with computer 16, which transmits all the data necessary to process the rough contour model 15 to the process data processing 42, and if necessary all data necessary to process the plate material 12, per se. For example, it is not necessary to join all slice blanks 13 into one rough contour model 15; instead, it is also possible to place uncut plate material on the fixing rods 24 against the rough contour model part already created, and then to cut out a slice blank 13 using laser beam 14.

The computer 16 presents the laser performance  $P_L$  to the laser 23, as well as additional scaling of its switch-on duration, with a pulsed laser 23, so impulse length and impulse frequency. The process data processing 42 completes the control of the laser 23 through  $\pm\Delta P$  and  $P_L$  ON/OFF. These values vary the laser performance  $P_L$  and the switch-on duration  $t_L$  in such a manner that the material area shown in fig. 4 is carried off with the next laser impulse or the next impulse chain. Previously, the process data processing 42 determined a value for an adjustment path  $\pm\Delta z$  and forwarded them to a stepper motor 43 which pushed the processing optics 22 in the direction on the target contour.

Upon reaching the listed target contour value, processing is stopped, and the processing optics are shifted by a section  $\Delta x$  corresponding to the diameter of the laser beam 14, in forward direction. Afterwards, processing is continued until the entire rough contour model 15 is polished or the model shape 18 has been reached. Afterwards, manually reprocessing as well as painting the model can follow.

Fig. 5 shows a model 10 whose model shape 18 consists of three part areas 27. This is a personal motor vehicle whose average part area 27 has a layer of slices arranged next to each other vertically, whose front and rear part area 27 have slices 11 horizontally layered. This has the advantage that areas that extend out far, for example the bumper area, can be modeled to a corresponding selected thickness of the plate material 12 by precise layering, without requiring extensive material removal when polishing.

The plate thicknesses shown in fig. 5 are only schematic. In order to produce the slice blanks 13 to mostly process free, the slices can be selected to be very thin, i.e. 1 to 2 mm.



- empty page -

3711470

Number:  
Int. Cl.<sup>4</sup> :  
Application date:  
Publication date:

37 11470  
B 23 K 26/00  
April 4, 1987  
October 27, 1988

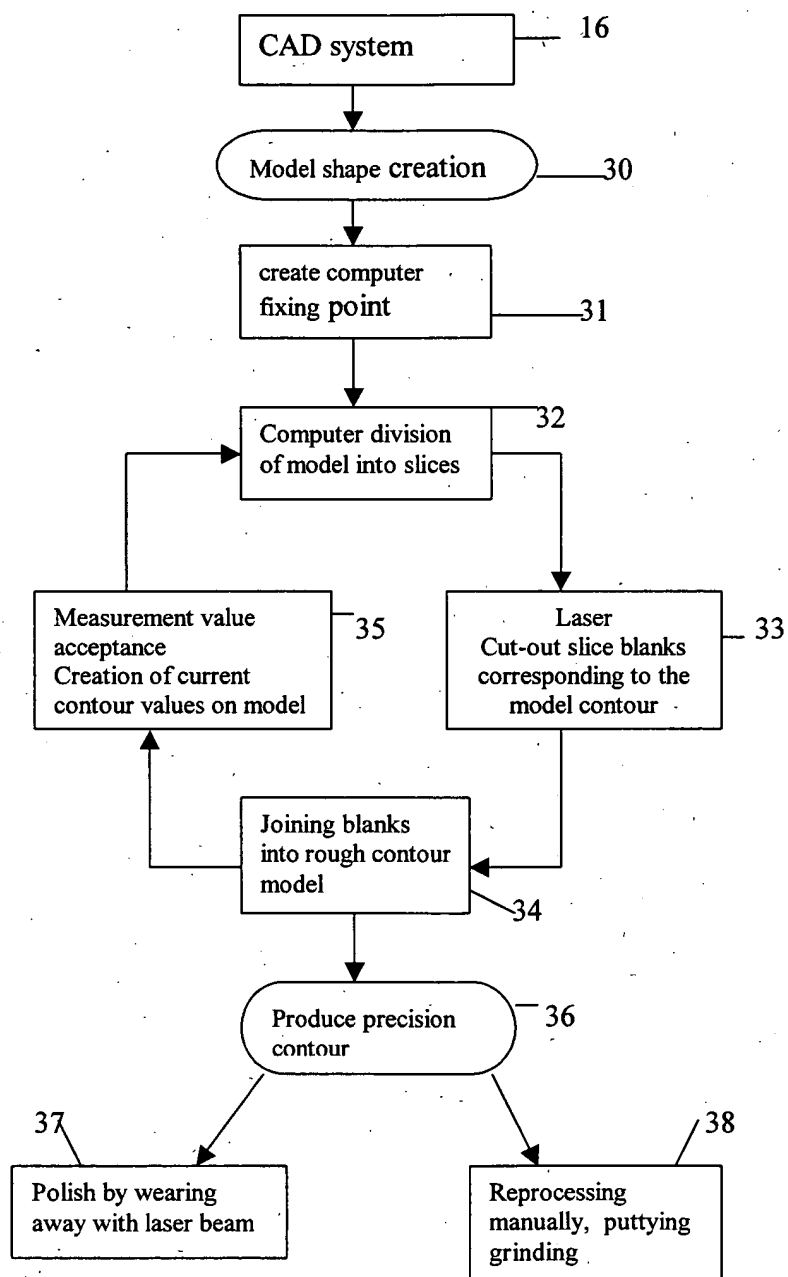


Fig. 1

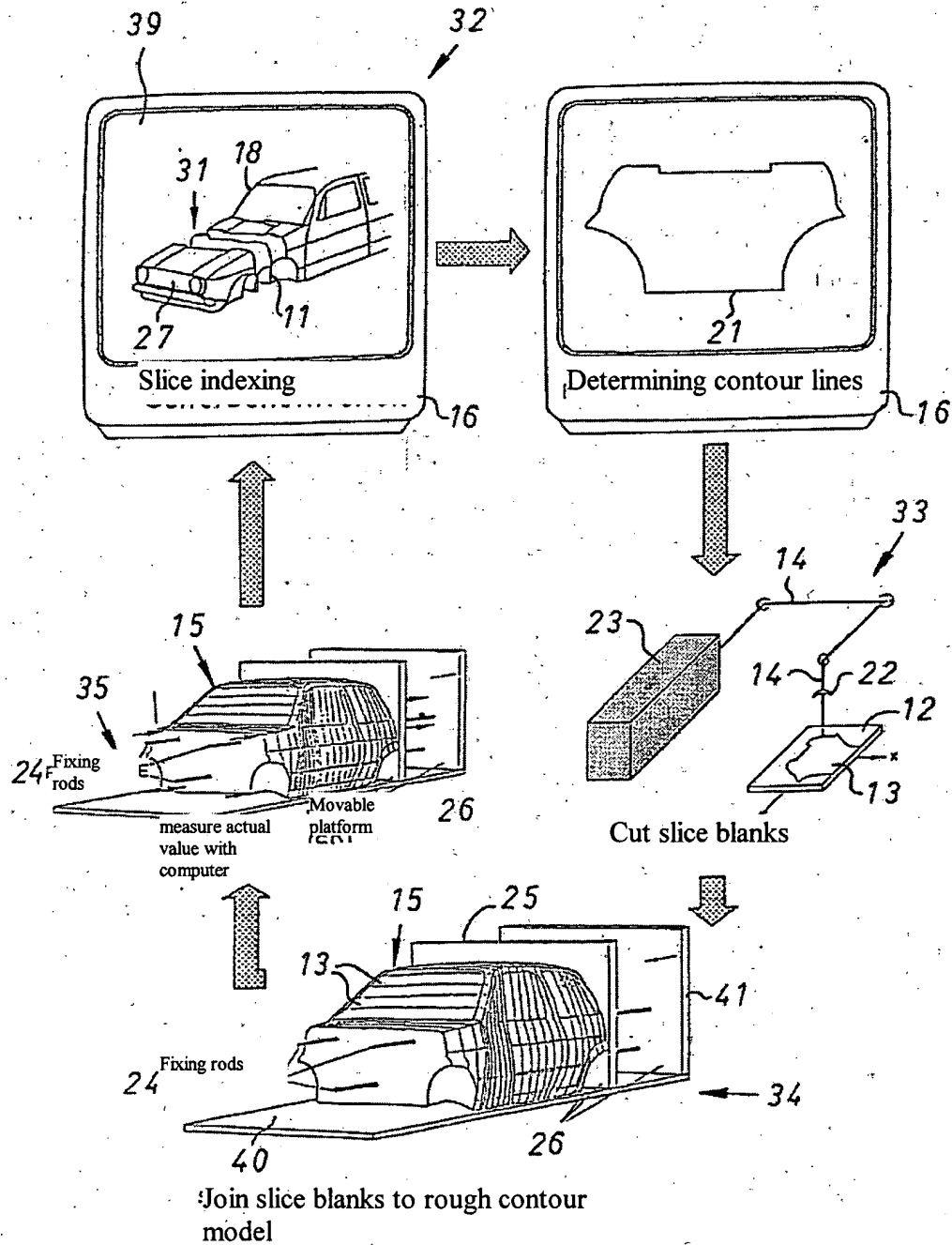


FIG. 2



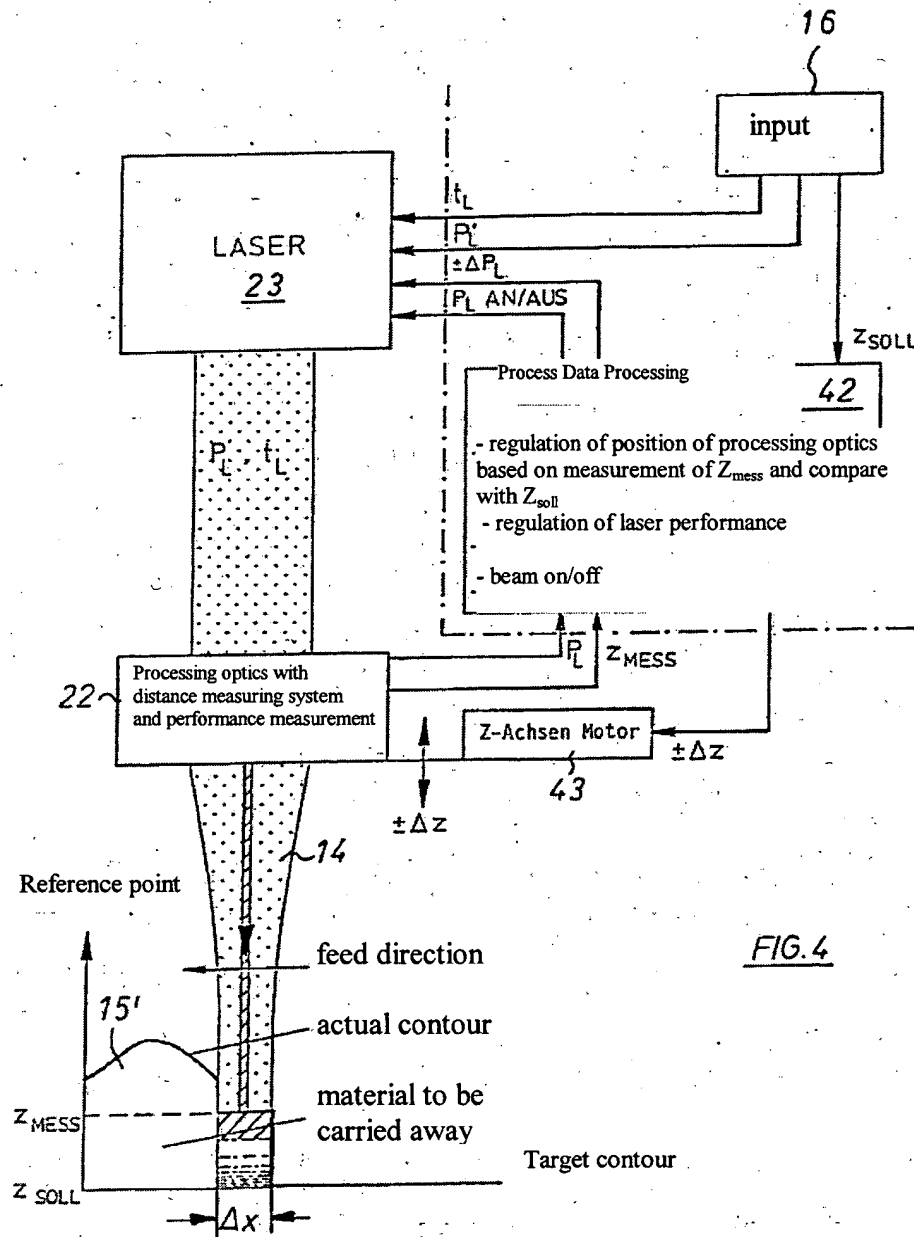


FIG. 4